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ABSTRACT

The problem investigated in this study was formulated against a background of the theory of affordance as it was tested with the famous "Visual Cliff" experiment. The present study is based on the assumption that perceivers can detect transformational as well as structural invariants not only in the context of the classical "Visual Cliff" experiments but also when their basic assumptions are transformed into the social realm. On the hypothesis that structural invariants can be defined as an invariant combination of variables of significance for the perception of social structure, a series of three factor analytic studies was conducted with a sample of 611 subjects. The first study involved 214 inservice teachers and 57 high school students in Sweden; the second study involved 180 residents of the Lund-Malmo area of southern Sweden; and the third study involved 160 university and college students in Sweden. The three studies were used to: (1) reduce an initial data set in the empirical approach to the Gibsonian concept of affordance; (2) extend the search for a two-component structure; and (3) confirm the existence of invariance in the affordance structure. Despite different sets of variables, different sample subjects, and a time interval of 7 years, it was possible to infer the existence of two ecological components defining the transformed "Visual Cliff". The first specifies the nature of change (the development of worth), while the second specifies the structure that undergoes change (the visibility of developed worth). (Author/TJH)

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The 'Visual Cliff' Transformed: A Factoranalytic Definition of Affordances

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Abstract

The problem investigated in this study was formulated against the background of the theory of affordance as it was tested with the famous 'Visual Cliff' experiment. The present study is based on the assumption that the perceiver can detect transformational as well as structural invariants not only in the context of the classical 'Visual Cliff' experiments but also when their basic assumptions are transformed into the social realm. On the hypothesis that structural invariants can be defined as an invariant combination of variables of significance for the perception of social structure a series of factoranalytic studies have been carried out with a sample of 700 subjects. Despite different sets of variables, different sample subject, and a time interval of seven years, it was possible to conclude the existence of two ecological components defining the transformed 'Visual Cliff'. The first one specifies the nature of change, i.e., development of worth. The second one specifies the structure that undergoes change, i.e., visibility of developed worth.

The Ecological Approach to Perception

Of fundamental importance in Gibson's (1979) ecological approach to perception is his theory of affordance. It is based on the assumption of a terrestrial environment provided with structure. What happens when this environment is perceived or conceived is that invariants are abstracted. Structural invariants make up its affordance. Gibson (1979, p. 134) defines an affordance as "an invariant combination of variables". Despite this definition, he has not been able to give it a formal definition nor has he, as he states in his autobiography, "achieved a promising hypothesis by means of factor-analysis" (Reed & Jones, 1979, p. 16). In formulating his theory of stimulus information, he conceives the sense organs as mechanisms adapted to environmental "reflectancies" of ecological information. Moreover he formulated the hypothesis that "description puts the optical invariants into words" (Gibson, 1979, p. 262). This means that the environment can be known when the medium for reflecting structural qualities is assumed to be conceptual relationships made visible in such a way that conceptual information can be detected and picked up by the sense organs. Furthermore, ecological perception implies a certain approach to the perception of motion and movement which depends on structured ambient light resulting from changes and persistences in the environment (Gibson, 1979, p. 151). Consequently, Gibson designed experiments with the purpose to operationalize his main concept of optical texture to account for the detection of transformational as well as structural invariants.

The 'Visual Cliff'

Gibson & Walk (1960) reported on an experiment with a very special kind of apparatus, known as the 'Visual Cliff'. It was constructed in such a way that perceptual differentiation could be studied on the basis of two orthogonally behaving dimensions. If the dimension specifying structural information was manipulated by expanding or contracting, this would result in perception of a flat surface. On the other hand, if the transformational dimension was manipulated, i.e., by changing the direction and length of contour lines, this would result in the perception of turning solid forms, i.e., depth perception.

On this premise, a table-like device was designed. It was covered with a perfectly clean solid glass top. The top was divided into two equally large halves. Both showed a textured surface constituting checker-squared patterns. By placing the texture at flexible hight below one half of the transparent glass top, an optical cliff was produced.

Through manipulating the line function, it was possible to illustrate that structural transformation produced edges on a surface.

The crucial problem for ecological perception is to demonstrate the behavioural significance of the optical information produced and its intentional use. Thus, an organism had to be introduced who could specify the observer's place in that environment, i.e., the point of observation. The way an organism with a certain history or path comes to meaning and understanding of the cliff was the primary problem studied by Gibson and Walk (1960), whose subjects were both children and animals. To run the experiments there had to be some action function. In the studies with infants they were required to locomote by crawling and to orientate themselves across the 'Visual Cliff', a task that could be performed through the experimenters' placing of a lure, such as the mother or a toy, at the other side of the table.

The results give evidence to the hypothesis of ecological perception, namely the existence of an external and objective world, which can be discovered on the basis of real or projected invariants. Moreover, Gibson (1979, p. 17) stated that stimulus information not only controls but constrains perception as well as behaviour. He concluded that a cliff can only be perceived if the individual can detect a surface layout. But that is not enough. The individual has to detect the affordance of this layout. With the specific texture gradient of the 'Visual Cliff', Gibson operationalized a negative affordance for locomotion, i.e., a dangerous place where the surface of support discontinues.

The implications of the experimental outcome of optical information processing are clear: The ecological perception of environmental change calls for measurement and representation in two dimensions. Therefore, measurement scales need to deal with variations in (1) the gradient of the optical texture surrounding the moving point of observation, and (2) transformational change specified by the angle of inclination , i.e., the expression of a mental dependency or preference. Consequently, the functions described below have to be defined in the construction of a 'Visual Cliff' and proper psychometric scales have to be designed for measuring its empirical outcome.

Optical texture. This consists of natural units which are nested within larger units. Optical texture constitutes the relatively fine structure of the ambient optic array providing for a wealth of transitions and overlaps. Neither for material nor for optical texture exists any proper and perfect unit in terms of which texture can be analyzed.

The organism. The hands and legs represent the motor activity. This can be, for example, touching or clapping the surface. Exploring or groping defines locomotor activity.

The action. The position and movement of the mother form the contextual basis for the locomotor activity of the child. To the extent that significant abstracted information can be perceived, it should be reasonable to expect that the perceiver makes intentional use of extracted ecological invariants.

For that reason, it is necessary to actually live in a certain environment or to anticipate living in that environment be it real or projected. Thus to perceive an environment comprises the coperception of oneself and one's living in the environment specified.

The 'Visual Cliff' Transformed

The representational function performed by pictures is essential for the projection of reciprocal relations conducive to the apprehension of affordances. But perceiving functional utilities depends on an adequate description of the conditions of life together with others and of what one's environment and other people offer. Picture perception means, therefore, the perception of the environment based on ambient optical structure which is not dependent on form but on formless invariants (Gibson, 1979, p. 271).

Optical texture. It was possible to use abstract environmental information which was commercially produced (see section: Materials). The factoranalytic studies to be presented in the following are based on the assumption that the perceiver should be able to come into contact with the existence of very different material and immaterial conditions as important aspects of particular environmental structures. For that reason, three picture series were used with the aim to narrate three environments, each based on a particular scientific concept. For example, the principle of cybernetics has resulted in the abstract representation of the implications of limits in interacting systems. In this case, the texture surface is layed out as a big city of today. Its functioning is portrayed through a young man, who on his way to the downtown area is confronted with power disconnection, outbreak of fire, bribery, corruption and robbery. The second principle which governed the controlled display of scientific reasoning was the principle of behaviour modification. Its optical texture is layed out as a community which attempts to integrate a young man who deviates from the values of the collective. This is attempted by directing him through reinforcement

contingencies. The third principle projected was the principle of evolution, both with respect to nature and culture. The optical texture is layed out as a community which emphasizes human's development of creative abilities, complete cooperation and personal fulfilment. This is materialized through a young man, who gets to know himself through the act of felling a tree with an axe. Through attention to mental processes he learns to enjoy physical and mental strain. With this texture gradient, the affordances of the environments should be directly perceived, because they are external to the perceiver.

The organism. The mental operation required for successful perception of the self acting within the constructed environments implies a "mental moving of one's point of observation", that is, an ego-orientation which is reciprocally specified. If the angle of inclination remains the same and an environment is stable, then it would be impossible tc extract structural invariants. The alternative hypothesis is that different degrees of inclination generate a visible path defined by successive points of observation. This path creates the flowing texture and is specified everywhere in this texture. The flow is assumed to contain the structural invariants. As long as the perceiver is sampling his viewpoints within the same optic array, the ego-orientation remains invariant.

The action. From a Gibsonian point of view, perceiving the particular affordance structure of a certain environment requires not only perceptual differentiation but also judgment in the form of a grading of the variables of stimulation. The perceiver needs optical contact with the textured surface related to the environment. But the perceiver also needs optical information for support, and this is a question of grading one's certainty about perceived stimulus information. Identified variables direct the process of visual attention, while the grading give expression to the degree of certainty that perceived structural strands are embedded in the textured surface. The subject is required to assess the degree of certainty with which a number of statements are assignable to the environment displayed. The richness of ecological information on one hand and its redundancy on the other have implications for the development of an instrument guiding this "locomotion". Any environmental properties, supporting statements which are not assignable, specify a perceptual mispath. Structural invariants specified by these properties are uncorrelated with the observational source and, by definition, carry nonsense. Furthermore, perceptual locomotion prerequires that the reciprocity of perceiver and perceived can be put into words. This mutu-

ality is thereby parceled into "quanta of language" and thus primitivized. Ecological information, in this sense, is an extraction of an ecological invariant defined over a set of verbal statements. In order to estimate the parameters characterizing the distribution of discriminal processes associated with a given certainty, a particular set of statements is needed to indicate a structure which is specific to the controlled display of pictured ecological information. What there is to be perceived has to be stipulated before its perceiving can begin. Consequently, the observation of mutual dependencies need to be based on variables, but not necessarily on all attributes possible. Instead, growing experimental evidence from research on impossible figures shows that higher order functions, i.e., invariants, have to be assumed as perceptual basis. The position and movements that can be taken by a person within his familiar surroundings form the anchorage of his assessment of an affordance. The way in which a person conceives of typical Swedish concerns is not displayed although the fact that optical texture is not projected to a point of observation does not mean that it is non-existent (Gibson, 1979, p. 79). Ecological invariants can be conceived through changing angles of inclination, as shown by the experiment on expanding shadows of Ball and Tronick (1971).

Factoranalytic Studies

As early as 1965 Cantril presented his social psychological study of patterns of human concern in 52 countries around the world. With the purpose of accounting for how people conceive qualitative aspects of their social environment he devised a rating form containing a five step ladder and asked people to indicate their wishes and hopes (upper bound) as well as their fears and frustrations (lower bound). He found that people could assess personal, social and national concerns within a five-year interval. Shifts on the ladder indicate shifts in judgment. Cantril treated distinguished concerns categorically and arranged them once and for all in the following classes of individual and social well-being:

1. Decent standard of living (nutrition and shelter).
2. Economic stability (personal consumption, security).
3. Political stability (high probability that the economic system will continue providing the elements of subsistence and the means of their purchase).
4. Social justice (creation of orderly and stable environments and enforcement of the law quickly,

uniformly and justly).

5. Emotional stability and maturity (pride in self, family, friends, community, and nation).

The same type of classes can be found in another social psychological study conerning the way in which Danes conceive states of crisis (Petersen, Kristensen, & Sabroe, 1987, pp. 101, 290, 293). For example, conceiving well-being is analyzed into items related to housing, leisure activities, clothing, medical services, education, security against old age and ill health as well as to income. In addition, the Danish study inquires into vigor and vitality which means physical and mental keenness, longevity, and freedom from physical and mental impairment. However, with an ecological perspective, the Danish researchers are on a mispath when they differentiate out a subjective and an objective aspect of their definition. The subjective part is labelled "well-being" which defines the degree to which the basic needs of a person are satisfied, and the members of the Nordic countries perceive themselves as products of affluent societies. The objective part is represented by the notion of "welfare" which defines the extent to which an individual has access to resources which make possible the steering and control of one's own conditions of life. The implications of ecological realism require the rejection of the dichotomy between "mental" and "physical" properties (Reed & Jones, 1982, p. 296), because the environment is neither subjective nor objective but exists independent of the psychological state of the perceiver.

What a certain environment offers was in the context of an explorative factoranalytic study indexed by means of the following classes:

1. Physical existence (adequate nutrition, dwelling and clothing).
2. Security (physical health, psychic health and prosperity).
3. Freedom of action (physical and mental vitality, freedom of choice and participation).
4. Efficacy (possession of adequate resources, shared responsibility, and economic investment).
5. Adaptability (legal rights, justice, and ability to change structure).

Every class was made the basis for formulating ten statements. Each statement was categorized into one and only one of nine certainty categories by means of the method of successive categories (Bock & Jones, 1968, pp. 212-244). For observational purpose a rating form containing 50

items were composed in such a way that the rating of each statement is independent of the rating of any other in the form. Therefore, its temporal position was independently randomized for each experimental subject and for each rating occasion.

Subjects. Eighty-eight special subject teachers, 139 remedial teachers and 59 High school pupils from grade 3 (=final) served as voluntary participants. The teachers were enrolled in the Malmö School of Education at the time of the experiment (March and April 1981), and the pupils came from the Public school physically connected to it. Because of the explorative nature of the study, careful sampling of subjects was not considered to be a decisive factor for data reduction and inference. However, different types of teachers were chosen, because they work together in Public school and have the authority of bringing about the values to younger generations. Consequently, a matching group of High school pupils who are just about to leave school and enter social life of young adults were also included. Of all subjects who participated, 62% were female. The mean non-response was found to be 5% which means that the scores of 214 inservice teachers and 57 pupils were finally processed.

Materials. The audio-visual material on "Projections for the future" was commercially produced in 1978 by the Biological Science Curriculum Study (P.P. Box 930, Boulder, CO, 80302) in cooperation with King Screen Productions of Seattle. The total set of materials consists of nine modules of which three narrate the three scientific principles used in the experiments. The sound-track of slides used were dubbed into Swedish. Furthermore, two slide projectors, manoevred by sound impulses from a cassette recorder were employed. The required viewing time were for the behaviour modification narrative 9 min. 24 sec., the evolution narrative 11 min. 32 sec., and the cybernetic narrative 10 min. 18 sec.

Design and Procedure. For rating purpose, 18 groups with about 15 members on the average were exposed to the narratives. At the first rating occasion, the subjects were always asked to indicate there observations and judgments of living in Sweden. Mostly for motivational reasons teachers and pupils studying (1) Arts, (2) Social Sciences, and (3) Natural Sciences were exposed to the audio-visually presented narratives in the following order:

1. Evolution, Behaviour modification, and Cybernetics.
2. Behaviour modification, Evolution, and Cybernetics.
3. Cybernetics, Behaviour modification, and Evolution.

Because of possible group, sex and order of presentation effects, the ratings were analysed by means of a multivariate strategy (Cooley & Lohnes, 1971, pp. 238, 316). No noticeable covariations were found (Bierschenk, 1987).

Results of the First Factoranalytic Study

Because it was possible to formulate statements about an affordance structure it is also possible to formally evaluate the degree of certainty in the perceived environmental properties and relations. To the extent that significant optical information has been picked up, it should be reasonable to expect a common characteristic or affordance basic to all environments.

In summarizing the obtained rating scores, each rating occasion may be considered to consist of a different set of subjects (= entities) (Bierschenk, 1971). This means that a subject on occasion one is conceived to be another subject on occasion two. On these grounds, the data for a specific occasion can be recorded as a conventional entity-item matrix. Furthermore, all data can be factoranalyzed within a supermatrix, where the elements are conventional matrices. After the performance of a series of analyses on the supermatrix it was possible to extract three factors as shown in Table 1.

One of the major problems in applying factor analysis models is to find the number of factors to be retained. Guided by the five provisional classes derived from previous research, it was expected that five factors could be extracted and identified. However, the results indicate great difficulties in formulating statements based on classes. It is only the first factor in the solution whose reliability (alpha $_{max}$ = .90) provides a formal and objective basis for a discussion of visual awareness. Furthermore, what has been perceived on the basis of the statements loading on the retained factors is factorially correlated. Since the emphasis is on objective measurement it is pointless to argue for or against orthogonal and oblique rotation, to find meaningful interpretations, or to attach a label to the second and third factor. All items correlated with these factors (42-54) are excluded from further considerations.

The statements (14, 4, 10, 6, 1, 26, 39) defining the first factor are worded as follows:

14. That I take personal initiatives is appreciated.
4. I have the right to live in accordance with my own values.

Table 1

Principal Component Analysis with Varimax Rotation toward a Three-factor Solution

Variable No.	Factormatrix 1	2	3	Factorpattern 1	2	3	Est. Com.
14	85	-03	-27	77	36	25	79
4	80	04	27	75	28	28	72
10	74	19	32	74	12	33	68
6	88	00	-16	72	40	35	80
1	84	09	-19	72	31	37	76
26	77	09	-14	63	29	37	61
39	60	01	-05	45	29	27	36
42	70	-46	12	37	75	06	70
43	67	-34	10	37	65	13	58
44	78	-33	-01	52	65	13	72
45	73	-36	01	48	65	09	66
46	40	-32	31	03	58	11	36
47	46	-30	20	15	55	10	34
48	43	53	22	16	02	71	52
49	47	55	11	26	-07	68	54
50	61	29	27	24	26	64	53
51	71	15	20	35	38	55	56
52	78	16	03	52	33	50	64
53	70	10	18	36	40	50	54
54	60	11	26	23	38	49	44
Lambda	9.87	2.00	1.21	Transformation Matrix			
%	49.40	10.00	6.00		1	2	3
				1	69	55	48
				2	04	-69	72
				3	-73	48	50

10. I can profess to the religion I want.
6. I can develop according to my own qualifications.
1. I can think and express myself freely.
26. I have an absolute right to information.
39. That I keep my promises is appreciated by others.

These statements describe a social atmosphere that offers the individual a relaxed expression of its own values, both in speech and way of living. It supports acting and offers access to public information. It seems as if Factor 1 represents a composite that exists in a social medium and affords the development of "Eigenwert", i.e., worthiness. The original meaning of the German word "Wert" (= worth) can be comprehended only in relation to the German word "werden" (= becoming) which means "set face against" what is offered by other people in one's milieu. The ecological implication is that perceptual sensitivity needs to be understood as the individual's ability to behave vermicularly. Thus, the meaning or value of something consists of what it offers and these offerings are reciprocally specified in the Gibsonian sense.

The results of first study show that one factor could be identified and described. If it is possible to reproduce this factor it would mean that the factor represents an invariant, i.e. an affordance. According to Gibson, it would be neither subjective nor objective but define the potential relation between the individual and its environment. Moreover, it would mean the establishment of an affordance that would exist independently of the perceiver's psychological state at the moment of observation.

The way in which one individual learns how to discriminate what others perceive and how this "kind of behavioral loop" (Gibson, 1979, p. 42) is built up determines the properties of the social atmosphere. The characteristics of this atmosphere are that they afford the perception of relational behaviour, whose meaning can be discovered. The previous study showed that Gibson's assumption of superordinate components can be used to establish "development of worth". The aim of the following factoranalytic investigation is to use the semantic context of the concept of worth as controlling device for refining the instrument for observation and to extend further the search for an affordance structure.

The course of action taken in the construction of a new rating form followed an entirely different path compared to the first study. A group of seven doctorate students attending a behavioural science course on data collection and analysis was assigned the task to measure worthiness and to design a proper rating form. For that reason the students were asked to begin with an exploration in semantic definitions of the concept of worth.

The Semantic-Taxonomic Approach

This step involved the examination of a number of dictionaries of the

Swedish, English, German, and French languages. Two students, moreover, had extended their search to data bases such as Educational Resources Information Center, Psychological Abstracts, and Sociological Abstracts. They retrieved information on the subject covering the years 1980-1986. Another pair of students included the Bible in their search for definitions. Thus, each student were able to extract 40-60 attributes. The problem now to be solved required the construction of conventional data matrices, where the samples of dictionaries made up the rows and the identified attributes specified the columns of the matrices.

A first step in the analysis of the dictionary definitions required the calculation of distances in the transpose of the original matrices. Because of the presence-absence type of data generated, the use of distance is an appropriate measure. This means that the distance between two attributes (A, B) in a swarm of points, representing all attributes, can be quantitatively expressed. The distance was measured according to Ward's (1963) method: It is expressed as the total sum of squared deviations of every attribute from the mean of the attributes of the cluster to which the attribute belongs. At every cycle in this process, the pairs of attributes or clusters are brought together, whose amalgamation minimizes the loss of information, expressed as a minimum increase in the error sum of squares. The most desirable value of this function is a minimum value of ESS = .000. The calculation procedure was executed with Wishart's (1982) Clustan program and has resulted in eight classifications, i.e., one per student.

The following clusters together with their proposed namings are examples of analytical concepts derived that way:

Intrinsic value	*Reputation*	*Reliability*
Composure	Dignity	Balanced manner
Peace of mind	Gravity	Position
Pride	Doctoral degree	Triumphal place
Highness	Honour	Nobility
Correctness		

At the empirical definition of the significant number of clusters in each of the eight clusterings, two premises have been decisive: (1) There is an obvious break in the resulting tree, or (2) the significance criterion ($p < .05$) can be applied. On the basis of this, seven or eight collinear clusters emerged and could be given meaningful interpretations. The interpretations had to be described verbally such that it became obvious to what degree the names were adequate prototypical descrip-

tions of the determined clusters.

On the basis of the differentiation of the concept of worth achieved by this taxonomic approach, each student was required to propose seven or eight statements, i.e., one for each identified cluster. Each statement had to be formulated in such a way that the meaning of the established differentiations could be conveyed to experimental subjects. The final rating form came to consist of 50 statements that resembled the format of the first study.

Subjects. One hundred and eighty subjects served as voluntary participants. At the time of the study (March and April 1986) all volunteers were residents of the Lund-Malmö area of Southern Sweden. One third of the sample consisted of lower division university students who were specializing in Social Science, Law, and Civil Engineering. Another third were adult part-time students who attended courses especially designed for industry and business. Some participants were professionals working at the Department of Business Administration and in Advertisement. Included were also a class of High school pupils from second grade, studying Business Administration. Of the total sample 47% were female. After an analysis of non-response the scores of 180 subjects could be processed.

Materials. With two exceptions the materials were identical to those of study 1. In the present study, (1) pictures and sound were kept in its original form and (2) transferred onto videotape.

Design and procedure. The design and procedure were identical to those of Study 1, except that pairs of students acted as data collectors. Each pair was assigned the task of finding 40 subjects who were willing to participate although one pair collected data from 60 subjects. After control of possible systematic errors resulting from an experimenter effect or the use of one and the same subject repeated times (Bierschenk, Helmersson, & Lohmander, 1987) the supermatrix was factoranalytically evaluated.

Results of the Second Factoranalytic Study

The strategy followed in the extraction and definition of a minimum sufficient number of factors were in agreement with the criterion applied in Study 1. As is shown in Table 2, two factors are sufficient to reliably account for the covariances.

The estimated reliability value for the first factor is alpha $_{max}$ = .95 and for the second factor alpha $_{max}$ = .77. Moreover, the transformation

Table 2

Principal Component Analysis with Varimax Rotation toward a Two-factor Solution

No.	Factormatrix 1	2	Factorpattern 1	2	Est. Com.
2	83	01	83	04	69
11	83	08	83	12	70
3	82	03	82	07	68
7	80	-04	80	-01	65
40	80	03	80	06	64
13	78	02	78	06	60
5	76	-13	77	-10	60
19	76	-04	76	-01	58
12	73	-08	73	-05	54
15	68	-07	68	-05	47
20	66	03	66	07	44
30	66	01	66	05	44
29	63	02	63	05	40
25	58	-00	58	02	34
34	54	-08	54	-06	30
35	01	73	04	72	53
32	06	70	03	70	50
37	12	62	10	62	39
41	01	60	03	61	36
Lambda	8.46	2.35	Transformation Matrix		
%	44.50	12.40		1	2
			1	1.00	.04
			2	-.04	1.00

matrix indicates a pure rigid rotation in contrast to that of the previous study. This means a perfect orthogonal projection of both factors in the rotation. Since the factors behave orthogonally to each other, two independent dimensions can be specified. The statements loading on Factor 1 are the following:

2. I have the freedom to express my own opinions.
11. I have the freedom to chose myself the literature I want to read.

3. I can chose freely my political opinions
7. I can on my own form my life.
40. I may have any religious conception I want to.
13. I can together with my wife/husband decide upon when and how many children we want to get.
5. I dare be myself.
19. I can myself decide where I want to live.
12. The society allows me to fight for my ideals.
15. My power as an individual is tolerated.
27. I can myself chose my clothing.
20. I need not ask others when I shall carry out some action.
30. I have the freedom to chose my childrens' education.
29. I am never forced to join meetings I don't care for.
25. I can influence the society's norms.

To what extent these statements describe the same dimension as was found previously can be decided upon on the basis of "marker variables" (Horst, 1965, p. 241; Rummel, 1970, p. 212). In order to ensure sufficient overlap between the first and second investigation, four reworded marker variables (2, 40, 5, 20) were included. Despite different sets of variables, different samples of subjects and a time interval of five years, it is easy to recognize a simple structure in the factor solution of Table 2, whose first dimension is the same as that of Study 1. Variables loading high on the first factor at both measuring occasions show virtually zero projections on the second factor. Thus, each variable projecting on the first dimension may be regarded as a pure measure of an invariant.

The second factor represents a new dimension. The variables loading high on this factor show essentially zero projections on the first. The following statements belong to Factor 2:

34. I am treated differently if I have a formal title.
35. My status is dependent on where my place is situated.
32. My status in the society depends on my education.
37. My reputation depends on which persons I am together with.

Factor 2 seems to represent the "shell" around worthy change in the individuals path of becoming (in German: Werdegang). Visual awareness of worthy others and societal attention to worthy change seem to require that form or shape has to be imposed on individual progress if

it shall become visible. Thus, visibility of developed worth depends on an organized expression of the formal properties of personal distinctness, i.e., status.

The results of the second study give evidence to the existence of two orthogonally behaving higher order components. With an ecological perspective on these results it can be stated that the reciprocity of individual and environment can be defined factoranalytically. The conclusion to be drawn from this definition is that the perceiver requires optical information for support. He would feel very uncomfortable with an invisible ground for worthiness. The emergent factoranalytical definition of Gibson's concept of affordance, thus far, is dependent on an a priori hypothesis and two orthogonally behaving components, i.e., dependent on the semantic approach outlined. One cannot disregard, however, the possibility that this definition of the information for perception does not convey sufficiently well the reciprocity of individual and environment. Perhaps the construction of statements based on the generation of natural text such that individual perspectives can be brought into play, would alter the definition.

In what way a perceiver picks up environmental properties and to what extent he can put his awareness into words are the questions that have governed the methodological approach of the following investigation which has been designed in order to confirm the possible existence of a two-component affordance structure. Therefore, a new group of eight doctorate students attending the same course on research methods were asked to produce three separate verbal descriptions of the projected environments. The following instruction was given:

"You will be shown a videotaped picture series about a vision of a modern society extrapolating current trends. The purpose is to give you the opportunity to put yourself into this society. You are asked to orientate yourself in such a way that you can derive a pronounced conception of what kind of basic conditions will influence your life in case you would live there. After the display you are asked to give an account of your orientation within the society shown. You may want to utilize some events or character you find worth serious consideration. Please narrate as naturally as possible. Give your narration a forward flow. Circumvent unnecessary corrections."

The generation of text material should allow each student to put his or her (= one female) own perspective into the textual flow. Note that the instruction implies that visual awareness of the environment and the

coperception of self are inseparable in this situation.

The first videotape shown to the group displayed the cybernetic narrative. This narrative was chosen, because it portrays a highly advanced technological society with its typical problems of (1) limits to resources and dispose, (2) insufficiency of scientific knowledge, and (3) lack of moral and ethical concerns.

On the average the narrative elicited one A-4 page of handwritten text which required about 30 minutes for creation and production. This procedure was repeated for the other two narratives at the same occasion. The aim with the texts thus created was to let each student perform a content analysis. It was expected that the students in applying such an analysis independently of each other would be able to describe specific properties at the ecological level. Moreover, it may be hypothesized that this procedure would enhance the realism in the measurement of visual awareness.

- *The content analytic approach.* The technique suggested to the students was to develop coding instructions and to construct a frequency-based classification system. In constructing the system, they were aided by the procedures described in Bierschenk (1978). Furthermore, they were required to give their classes descriptive definitions and provide particular examples of categorized "information units" to be put into a specified class. The following examples are prototypical of classes derived from the texts:

Class: Conditions of life.
Example: People seem to be working at top pressure. Power and money govern the individual.
Definition: Designates housing standard and income conditions as well as social class association. Even differentiation into professions is to be included.

Class: Social milieu.
Example: Once designed for collective happiness.
Definition: Descriptions characteristic of social milieu, i.e., relations among people.

Class: Strategies of survival.
Example: He must fight against himself and his own images.
Definition: Different conducts and patterns of life for survival. Survival with the implication of "stand

it" and "manage to live" even to the expense of physical death in a near future.

The examples illustrate various directions and orientations in the students' construction of the classification systems. Different perspectives governed not only the individual categorizations but also the way in which each student found his classes. After initial classification attempts based on the first text each student was asked to process the other two pertaining to the evolution and behaviour modification narratives. It turned out that the expansion of the individual classification systems by this measure was negligible.

The next step in this procedure required everyone to determine the intersubjectivity of his or her classificational effort. The group was split up into pairs. Each pair had to reclassify each other's items. The intersubjectivity of a classification was measured with Scott's index (pi) (Scott, 1958) which corrects not only for the number of classes in a particular set, but also for the probable frequency with which a class is used. The coefficients reported in Table 3 show to what degree measures with the same classification system on a given set of categories yielded similar results. On the whole, the coding result shown in Table 3 appear to be in line with values reported internationally in the literature on content analysis (Bierschenk, 1978, pp. 58-59).

Diversity of outlooks seem to be the decisive factor determining the results of pair no. 4. In this case both students had to rely upon as-

Table 3

Intersubjectivity Measures for Eight Classification Systems

Group No.	Individual No.	Classes in set No	Scott's pi
1	1	15	.73
	2	14	.84
2	3	7	.64
	4	5	.63
3	5	9	.74
	6	5	.61
4	7	12	.16
	8	8	.37

pects of their experiences that are culturally very different in kind. As the given examples indicate, no one student had categorized in the same way as any other, nor defined any class such that it resembled the definition of a similar class defined by any other student. Problems arising from these circumstances are typical for all content analysis procedures and has plagued this type of research since its beginnings (Pool, 1959). Psychometricians (e.g. Horst, 1966) regard text production and consequently content analysis procedures inappropriate for psychological measurement and argue uncompromisingly in favour of an a priori definition and grading of verbal expressions.

However, the insufficiencies of content analysis can be counteracted by applying simple psychometric logic, i.e., by letting the 75 classes constructed by the students constitute their consensus of abstracted ecological properties. Hopefully, this will improve the measurement more rapidly than accumulate measurement error. The advice given to the students was to put the conceptual structure of their respective classification into four to six statements. This effort resulted in 34 statements which were formatted according to the previous studies.

Subjects. One hundred and sixty lower division university and college students served as voluntary participants. Half of the subjects came from Lund University, the other half from Växjö College, which is situated in another region of Southern Sweden. At the time of the study (April 1988) all students were attending courses in Economics and Business Administration.

Materials. For replication purposes the 26 reliable variables of the first two studies were used as marker variables with the aim to maximize the generalizability of the simple structure found in Study 2.

Design and procedure. The design and procedure were identical to those of Study 2.

Results of the Third Factoranalytic Study

The goal now is to find a solution that is not dependent on a particular mixture of variables. The hypothesis tested is whether and to what extent the factor solution of Study 2 can be reproduced, i.e., is invariant. This concept of invariance underlying the simple structure criterion enables one to segregate a set of variables as long as marker variables highly loaded on a simple structure factor are included, regardless of the inclusion or exclusion of variables unrelated to the set. The results of the final factor solution are given in Table 4:

Table 4

Principal Component Analysis with Varimax Rotation toward a Two-Factor Solution

Var. No.	Factormatrix 1	2	Factorpattern 1	2	Est. Com.	Corr. r	Alpha Item
1	92	02	92	01	85	91	98
2	90	-02	90	-02	81	89	98
3	89	07	89	07	80	88	98
4	88	-04	88	-04	78	87	98
5	88	-11	88	-11	78	87	98
6	88	-03	88	-03	77	86	98
7	87	-08	87	-08	77	86	98
8	86	00	86	00	74	85	98
9	85	05	85	05	73	84	98
10	85	04	85	04	73	84	98
11	85	13	85	12	74	84	98
12	84	-06	84	-06	71	83	98
13	84	05	84	05	70	82	98
14	83	-04	83	-04	69	82	98
15	83	-14	83	-13	70	81	98
16	81	00	81	00	66	80	98
17	81	13	81	13	67	79	98
18	79	-09	79	-09	63	77	98
19	78	-10	78	-10	63	77	98
20	77	-00	77	-00	60	76	98
22	77	-09	77	-09	60	75	98
22	76	18	77	18	62	75	98
23	73	-03	73	-03	54	72	98
24	73	-03	73	-03	53	71	98
25	72	-13	72	-13	54	70	98
26	72	03	72	03	51	70	98
27	70	07	70	07	49	68	98
28	69	17	69	17	50	67	98
29	63	-04	63	-04	40	61	98
30	62	15	63	15	41	60	98

Table 4
(Cont.)

Var. No.	Factormatrix 1	Factormatrix 2	Factorpattern 1	Factorpattern 2	Est. Com.	Corr. r	Alpha Item
31	-01	76	-01	76	58	66	83
32	-14	75	-13	75	58	65	83
33	12	74	12	74	57	65	84
34	-10	73	-09	73	54	63	84
35	-09	71	-08	71	50	60	84
36	11	70	12	70	50	60	84
37	-13	64	-13	64	42	53	85
38	22	61	22	61	42	49	85
Lambda	19.51	4.22	Transformation Matrix				
%	51.30	11.10		1	2		
			1	1.00	-.00		
			2	.00	1.00		

A simultaneous look on both variables and configuration rule out any danger of misinterpretation. Both factors have been reproduced within the same structural configuration as in Study 2. While ten new statements are projecting highly on the first factor, four new statements give more weight to the second factor. The very high reliability values of the first factor (alpha $_{max}$ = .98) and the second factor (alpha $_{max}$ =.87) indicate a noticeable enhancement of the measurements.
The statements added to Factor 1 are the following:

8. I have the possibility of movement both within and outside my municipality.
9. I can freely develop my personal talents.
16. I have the possibility to be alone when I want to.
17. I can participate freely in organized opposition against the ruling authority.
18. I can handle the problems that come up in life.
21. I can adapt my actions according to situational demands.
22. I can freely chose profession according to my interests.
23. I do only those things I want to do.
24. I can actively contribute to re-evaluations in the

society.

28. I can develop my competence within my work.

The ecological properties captured by these statements enhance the basic meaning of becoming. Thus, an individual's competent and conscientious conduct refers to an ability to adopt socially useful skills and to cope successfully with environmental change. In this sense "becoming" has some loose connection to Maslow's concept of "self-actualization" (Maslow, 1954, p. 91; 1968, p. 25). He based his concept of "self-actualization" on categorically derived classes and a predesigned hierarchy. In illustrating the highest level of this hierarchy he did mention such attributes of the social environment as freedom of speech and action. The present factor represents an entirely different approach and dimension. Its mathematical defintion does not resemble any partitioning of ecological information for classificational purposes. The statements added to Factor 2 are the following:

31. I face new technical solutions in my everyday life.
33. My position in the society depends on my education.
36. I can improve my well-being by making use of technical novelties.
38. I can provide for my demands for tangible assets.

Utilization of technical advancement and the standards of living further enhance individual distinctness and segregation, i.e., separation and order. The additional properties captured by these statements contribute to an improved degree of visibility and thus materialize the factor further.

The salient characteristic of the simple structure reproduced by the third study is that the correlations between the variables could be explained without employing any control on the initial location of the factors in the configuration of vectors. Exercising control by maximizing the variance through altering the location of the factors did not add any new information to the psychological interpretation. Finally, it should be noted that the factoranalytic results give evidence to remarkably stable invariants.

Discussion

Three factoranalytic studies were used to (1) reduce an initial set of data in the empirical approach to the Gibsonian concept of affordance, (2) extend the search for a two-component structure and (3) confirm the existence of invariance in the affordance structure. The studies give strong support to the ecological hypothesis that a two-dimensional

tion between perceiver and perceived. What is perceived is characterized by two orthogonally behaving components. The studies show that the perceiver discovers these basic components of optical stimulation. These are not only invariant in magnitude and direction but also across normal individual patterns of change.

Because it was possible to empirically approach the Gibsonian concept of affordance, it was also possible to give its properties and relations a formal expression. For that purpose the method of successive categories was used. Despite the fact that the environments were judged on the basis of different sets of items, different samples, sex and age groups and over a range of seven years, the results of the studies show a remarkable uniformity in the judgments. Of theoretical significance for ecological information processing is that the recognition of the affordance structure shown, is not a function of age. If there is information to be perceived, its underlying affordance will be discovered.

It shoud be noted that the two-factor solution gives evidence to the existence of the property of invariance. This property holds mathematically for "any two-factor matrix" (Kaiser, 1958, pp.194-195; Rummel, 1970, p. 393). The first dimension represents a composit describing the properties of a social medium, which affords the development of 'Eigenwert', i.e., worth. The ecological implication is that perceptual sensitivity needs to be understood as the individual's ability to behave vermicularly. The second dimension consists of a composit which describes the imposition of form. Its implication is that shape has to be given to worthy change if it shall become visible. Thus the meaning or value of something consists of what it offers and formal properties of personal distinctness and hence segregation, i.e., separation and order.

References

Bali,W., & Tronick, E. (1971). Infant responses to impending collision: Optical and real. *Science, 171*, 818-820.

Bierschenk, B. (1971). *Att strukturera olika datanivåer med hjälp av factoranalystekniker* (Structuring different data levels with the help of factoranalytic techniques). (Kompendieserien, No. 12). Malmö, Sweden: Lund University, School of Education.

Bierschenk, B. (1978). *Innehållsanalys som forskningsmetod* (Content analysis as research method). (Kompendieserien, No. 25). Malmö, Sweden: Lund University, School of

Education.

Bierschenk, B. (1987). *Perception of quality of life* (Kognitionsvetenskaplig forskning, No. 16). Lund, Sweden: Lund University, Department of Psychology.

Bierschenk, B., Helmersson, H., & Lohmander, B. (1987). *Worthiness as behavioural component* (Kognitionsvetenskaplig forskning, No 17). Lund, Sweden: Lund University, Department of Psychology.

Biological Sciences Curriculum Study, & Crystal Productions (1976). *The program guide to projections for the future.* Boulder, CO: Biological Sciences Curriculum Study.

Bock, R.D., & Jones, L.V. (1968). *The measurement and prediction of judgment and choice.* San Francisco: Holden-Day.

Cantril, H. (1965). *The pattern of human concerns.* New Brunswick, NJ: Rutgers University Press. Cooley, W.W., & Lohnes, P.R. (1971). *Multivariate data analysis.* New York: Wiley.

Gibson, E.J., & Walk, R.D. (1960). The "Visual Cliff". *Scientific American, 202,* 64-71.

Gibson, J.J. (1979). *The ecological approach to visual perception.* Boston: Hougthon Mifflin.

Horst, P. (1965). *Factor analysis of data matrices.* New York: Holt, Rinehart and Winston.

Horst, P. (1966). *Psychological measurement and prediction.* Belmont, CA: Wadsworth.

Kaiser, H. F. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika,* 23, 187 -200.

Maslow, A.H. (1954). *Motivation and personality.* New York: Harper & Row.

Maslow, A.H. (1968). *Toward a psychology of being* (2nd ed.). Princeton, NJ: Van Nostrand.

Petersen, E., Kristensen, O.E., & Sabroe, K. (1987). *Danskernes tilvaerelse under krisen* (Vol. 1). Aarhus: Aarhus Universitetsforlag.

Petersen, E., Sabroe, K., & Sommerlund, B. (1987). *Danskernes tilvaerelse under krisen* (Vol. 2). Aarhus:

Aarhus Universitetsforlag.

Pool, I. de S. (Ed.) (1959). *Trend in content analysis.* Urbana: University of Illinois Press.

Reed, E., & Jones, R. (1982). *Reasons for realism. Selected essays of James J. Gibson.* Hillsdale, NJ: Erlbaum.

Rummel, R.J. (1970). *Applied factor analysis.* Evanstone: Northwestern University Press.

Scott, W.A. (1958). Reliability of content analysis: The case of nominal scale coding. *Public Opinion Quarterly, 19,* 321-325.

SPSS. (1986). SPSSX(TM) (2nd ed.). New York: McGraw-Hill.

Ward, J.H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association, 58,* 236-244.

Wishart, D. (1982). *Clustan: User manual* (Inter-University Research Council Series No. 47). Edinbourgh: Edinbourgh University, Program Library Unit.

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